of very common but most ancient potsherds indicate the existence of an ancient rustic habitation, which Homer appears to have described to us as the house and station of Eumæus. This is the more probable as at a very short distance to east of this site, and near the sea, is a white cliff with a perpendicular descent of 100 feet which until now is called Korax—*i.e.*, the Raven Rock, to which Homer refers when he represents Ulysses as challenging Eumæus "to precipitate him from the great rock" if he finds that he is telling lies (Od. xiv. 398). Below the Korax, in a recess, is natural and always plentiful pure water, which the tradition identifies with Homer's fountain of Arethusa, from which Eumæus's swine were watered. Dr. Schliemann excavated as well in the stables as in front of them on the site of the rustic habitation; the stable he found filled with stones, but on the site of the house he struck the rock in a depth of one foot, and found there fragments of very interesting, most ancient, unpainted pottery, also of pottery with red bands, and masses of broken tiles.

Dr. Schliemann states that Ithaca is, like Utica, a Phœnician word, and means "colony," and that the type of the Ithacans is decidedly Phœnician. According to Homer Laertes's grandfather was Poseidon, and Mr. Gladstone is therefore perfectly right that the descent from Poseidon always means "descent from the Phœnicians."

Dr. Schliemann has obtained a new firman for Troy. He left Athens on September 18 for the Troad to continue his long interrupted excavation of Troy. His first work will be to bring to light the whole of the mansion immediately to the north and north-west of the gate, which seems to belong to the ancient city's chief or king.

ARE THE "ELEMENTS" ELEMENTARY?[1]

THE problem set before us by the words which I have chosen as a heading for this article is a vast one; unfortunately the data upon which an answer must be founded are in themselves vague and meagre. It is useless attempting to draw an exact conclusion from inexact data. If the degree of probability which attaches itself to the data is small, the probability of the conclusion being true must be yet smaller.

In the times of the ancients men do not appear to have attached any very definite idea to the word "Element." An element was a something, a material or an imaginary something—it did not very much matter which—a something which one might suppose, if one were so minded, to form a sub-stratum upon which other, apparently more complex, things rested. Fire was an element; it was supposed to enter into the constitution of matter of many kinds. Some people said they believed that fire and water formed earth of different kinds; others averred that air and water were the foundations of all things. But it was perfectly legitimate for a third person to tell the two former that they were completely in error, that *really* sulphur and salt were the primary elements, and that from these all other forms of matter arose.

No exact data concerning the possibility of transforming earth into air, or water into fire, or salt into sulphur were forthcoming. Men did not generally trouble themselves with investigations into the actual properties of the so-called elements. Everything was founded on supposition; the human mind was superior to nature, and could project itself upon nature and explain nature.

Such a method could lead to no true knowledge of natural phenomena. To-day we have altered our method of investigation. Nature presents us with a mass of materials; most of these we can decompose into two or more forms of matter, but some of these resist all efforts hitherto made to effect their analysis. The latter we call elements, the former compounds. Our knowledge is imperfect; we acknowledge the imperfection, but attempt to make the knowledge *exact so far as it goes*. Whether the so-called elements are or are not capable of further subdivision is an open question. Whatever answer this question may finally receive, the superstructure of chemical science will remain unshaken. We may find it necessary to alter the form of many statements; the facts and, I am persuaded, many of the theories, will remain.

An element is then a substance which has hitherto yielded no simpler form of matter than itself. We make the hypothesis that matter is built up or compounded of those substances which we call elements. But this is of course only an hypothesis. So long as we accept it as such it is of the utmost service to us; whenever we erect it into a dogma it ceases to become an aid to the investigation of nature, and begins to exercise a tyranny over us.

An amusing and instructive instance of the narrowing and deadening effect of accepting an hypothesis dogmatically is narrated in Prof. Bryce's recently-published book on Trans-Caucasia. Prof. Bryce accomplished the ascent of Mount Ararat: tradition says that no one has ever been to the summit of this mountain; the inhabitants of the neighbouring country have formed this saying into a dogma which teaches that no one can ascend to the top of Ararat. When Prof. Bryce told the Archimandrite of the district that he had been to the summit the old man only smiled a sweet, sad, pitying smile, and said it was impossible.

The more modern history of the chemical elements warns us against dogmatising concerning the nature of these bodies. Potash and soda were classed among the elements until the year 1807. Water was for ages regarded as elementary; Cavendish first taught us that the long-cherished tradition was false.

The problem of the nature of the elements is one which requires the use of the imagination; it is a problem in endeavouring to solve which we are very ready to give the reins to this faculty, or rather to allow the lower power of fancy to usurp the place of the more divine imagination—and thus we run riot. The naturalist who approaches the investigation presented by the chemical elements had need to learn the scientific use of the imagination.

Many years ago an hypothesis was started by Prout to the effect that the elements are all compounds of hydrogen, that hydrogen is the primary form of matter, and that the molecule of each element is composed of a varying number of atoms of hydrogen. If this hypothesis were correct the combining or atomic weights of the elements would be simple multiples of the combining or atomic weight of hydrogen, *i.e.*, multiples of 1. The experiments of Dumas lent support to the hypothesis of Prout, but the later and more exact researches of Stas negatived the idea.

Stas showed, in a wonderful series of investigations, that the atomic weights of the elements are not simple multiples of 1, nor of $\frac{1}{2}$, as Dumas had supposed, but that they are fractional numbers. Stas further showed that the same number, as representing the atomic weight of a given element, is obtained by different processes of investigation.

But may not Prout's hypothesis have some truth underlying it? Are the elements really elementary? Stas's researches do not answer this question. We may put the general question in two forms. Are the elements compounds, in varying proportions, of a few simple bodies? or, Are the elements compounds, in varying proportions, of *one* primary form of matter? Let us look at these questions in succession—and first we may frame the hypothesis that the elements are compounds of a few simple bodies.

In order to learn what are the general properties exhibited by a series of bodies all of which are compounds,

[1] A paper read before the Owens College Chemical Society.

in varying proportions, of a few simple bodies, let us consider one of the homologous series of hydrocarbons; say the marsh-gas series. CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12}, C_6H_{14}, &c., &c.; generally C_nH_{2n+2}. The members of this series are all compounds, in varying proportions, of carbon and hydrogen; each differs from the preceding by an increment of CH_2. The difference between the molecular weights (the weights of two vols.) of the members of the series is 14. The physical properties of the series show a gradation from the first upwards. The first is gaseous at ordinary temperatures: as we ascend the series we have liquids of gradually-diminishing liquidity, then solids, the melting-points of which gradually increase. The chemical properties of the series, so far as these have been investigated, also exhibit a regular gradation. If we divide the specific heats of these compounds by their molecular weights, we do not obtain the same number for each—in other words, the molecular heat of the members of this series varies: this is a point of some importance. The specific volumes—products obtained by dividing molecular weights by specific gravities determined at that point at which each vapour exerts the same tension, that is, at the boiling points of the liquids—of the members of this series differ by 22. A simple relation of some kind most probably exists between the densities of the members of this series, between the actions exerted by these bodies on light, &c., &c.

Take now a group of allied elements:—Oxygen (16), sulphur (32), selenium (79·5), tellurium (128). The atomic weights—or the molecular weights, whichever form is preferred—of the higher members of the series are multiples of the atomic weight of the first: $16 \times 2 = 32$, $16 \times 5 = 80$; $16 \times 8 = 128$. Oxygen is a gas, except under conditions of great pressure; sulphur melts at about 115°, selenium at about 100°, but a modification at 215°; tellurium at 450° C. There is a gradation in the general chemical nature of the four elements. There is a simple relation between the specific volumes of these four elements in the solid state; this relation is expressed by the numbers 1 : 3 : 3 : 4. The atomic heats of the three last-named substances are the same; the atomic heat of solid oxygen, as deduced from observations carried out on compounds, is rather less than the number representing the atomic heats of sulphur, selenium, and tellurium. I might adduce other series of elements, let one suffice:—

	Lithium.	Sodium.	Potassium.	Potassium.	Rubidium.	Cæsium.
Atomic weight =	7	23	39·1	39·1	85·4	133
Mean ,, =	—	23·05	—	—	86·05	—

The atomic weight of the second member of each subsection of this series is almost exactly the mean of the atomic weights of the first and third; in each case the number representing the atomic weight of the middle element is a very little less than the mean of the atomic weights of the elements at the extremes of the series. The specific volumes of the metals lithium, sodium, potassium, and rubidium (the specific gravity of cæsium is unknown) are respectively, 11·9, 23·7, 45·1, and 56·2; these numbers are nearly in the proportion of 1 : 2 : 4 : 5; there is a regular gradation, therefore, in the specific volumes of the members of the present series. The physical and chemical properties of the series show gradations, which, so far as they have been examined, appear capable of tolerably simple generalisation. The atomic heat of the five metals is represented by a (practically) constant number. Now most of these facts are quite in keeping with the hypothesis that the elements which I have noticed are compounds of simpler forms; the properties of the compounds of the homologous series, C_nH_{2n+2}, are in very many respects analogous with the properties of the two series of so-called elements to which I have drawn attention. There is, however, one important difference between a certain physical property of the homologous series and the same property as exhibited in the elementary series—the atomic or molecular heats of the elements are, with few exceptions, the same; the numbers expressing the molecular heats of the members of the homologous hydrocarbon series are multiples of each other.

"It seems a general law," says Berthelot, "that the molecular heats of polymerised radicles are multiples of each other, whereas the molecular heats of the elements are, with very few exceptions, identical." The apparent exceptions among the elements, we have good reason to believe, will be found to obey the rule when more exact investigations have been carried out. This difference between the molecular heats of the elements and the molecular heats of series of homologous hydrocarbons lessens the probability of the elements being really compounds, in varying proportions, of a few simple bodies; or at any rate, it leads us to believe that, as Berthelot says, the phenomena attending the decomposition of the elements—supposing them to be really compounds—must be different from the phenomena attending the decomposition of those bodies which we know to be compounds. Nevertheless, I think that too much weight may be attached to this fact of differences in molecular heats. We do know of many compound gases, gases in the formation of which a very considerable amount of condensation occurs, but which have almost identical molecular heats. We have whole series of similarly constituted groups of compounds having the same molecular heats, *i.e.*, provided we accept the ordinary formulæ for solid compounds as molecular formulæ. So that the mere fact that the elements have the same molecular heats need not, I think, be a bar in the way of regarding these bodies as compounds, provided we have other evidence pointing in that direction.

But I must now briefly consider the second form under which the general question of the nature of the elements presents itself, viz., are the elements compounds, in varying proportions, of *one* primary form of matter? As a matter of fact we know of compounds in varying proportions of the same elements; we know also of compounds in varying proportions of one and the same element. The facts which have been amassed concerning allotropy and isomerism must be of service in any attempt which may be made to answer the question we are now to consider.

It is generally possible to trace a simple relation between the specific volumes $\left(\frac{\text{mol. wt.}}{\text{Sp. Gr.}}\right)$ of the various members of a group of elements; we have seen that such a relation exists in the two groups already considered, viz., the oxygen group and the potassium group. But it is stated by F. W. Clarke, of Cincinnati, who has partially investigated this subject of specific volumes, that so far as experiment has gone, no simple relation can be traced between the specific volumes of allotropic modifications of one and the same element. This statement appears to me to assume an amount of knowledge which we really do not possess. Clarke finds for the specific volume of ordinary sulphur the numbers 10·4 and 15·6; for prismatic sulphur he finds a number varying from 16·3 to 16·7; there is no simple relation between this number and either of the former. But he has assumed that the atomic weight of each allotrope is the same, and we have no data warranting such an assumption; the knowledge which we do possess points rather to an opposite conclusion. I think I am right in saying that in the case of oxygen and ozone we do possess some accurate knowledge of the (relative) molecular weights of two allotropes; these molecular weights are different; hence, probably, the atomic weights of the allotropes are also different.

M. M. PATTISON MUIR

(*To be continued.*)